(12) UK Patent Application (19) GB (11) 2 207 999 (13) A

(43) Application published 15 Feb 1989

(21) Application No 8719136

(22) Date of filing 13 Aug 1987

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(51) INT CL⁴
F16P 3/14

(52) Domestic classification (Edition J):
G1A C12 C1 C3 C4 C6 C8 D10 D1 D4 G14 G17 G1 G4 G6 G9 MQ P16 P17 P9 R6 R7 S10 S3 S4 S5
U1S 1637 1872 2189 G1A

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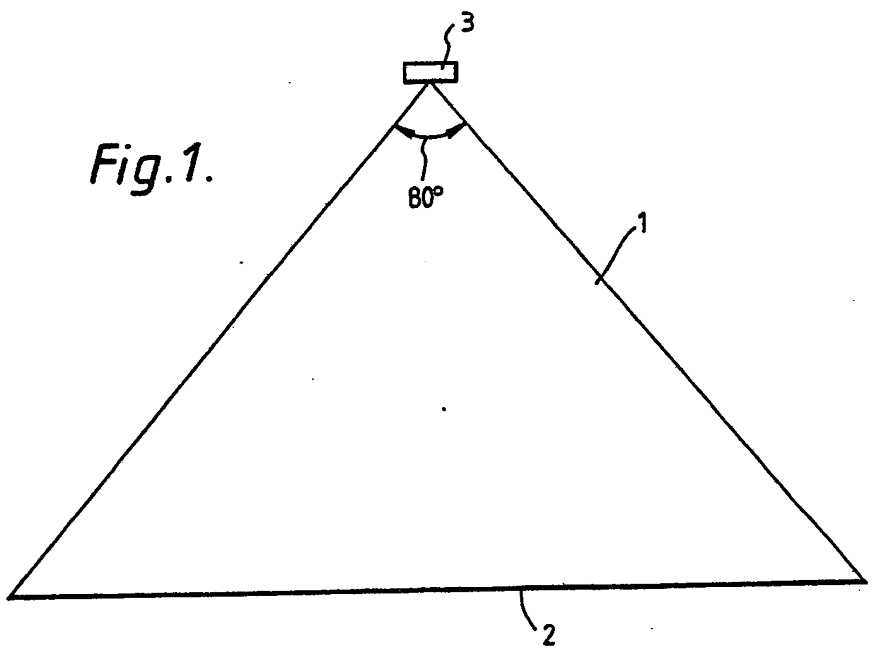
GB A 2166831 GB A 2034024 GB 1526987
GB 1436953 GB 1354456 EP A2 0220361
EP A2 0097139 EP A1 0021163 US 4742337
US 4384280 US 3987428
Note: EP A2 0220361 and US 4742337 are equivalent;
EP A1 0021163 and US 4384280 are equivalent;

(58) Field of search
G1A
G1G
H4D
Selected US specifications from IPC sub-classes
F16P G01N G08B

(54) **Safety systems**

(57) A safety system of the type in which an obstruction detector shuts down machinery when an obstruction is detected in the vicinity of the machinery, comprises a surveillance zone 1 which includes an illuminated reflector strip 2, a detector 3 for receiving reflected radiation from the strip and processing means for analysing the reflected radiation to determine the presence of an obstruction. The reflector strip 2 is illuminated by an IR LED array positioned adjacent an imaging array of photodiodes. The photodiode signals are read out in sequence and are thresholded to detect any region with a reflectivity significantly lower than that of the strip 2. This provides a precisely defined continuous "curtain" of sensitivity over a wide area and avoids regions within the area which are unprotected or insensitive to the presence of obstructions.

Fig.1.

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The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

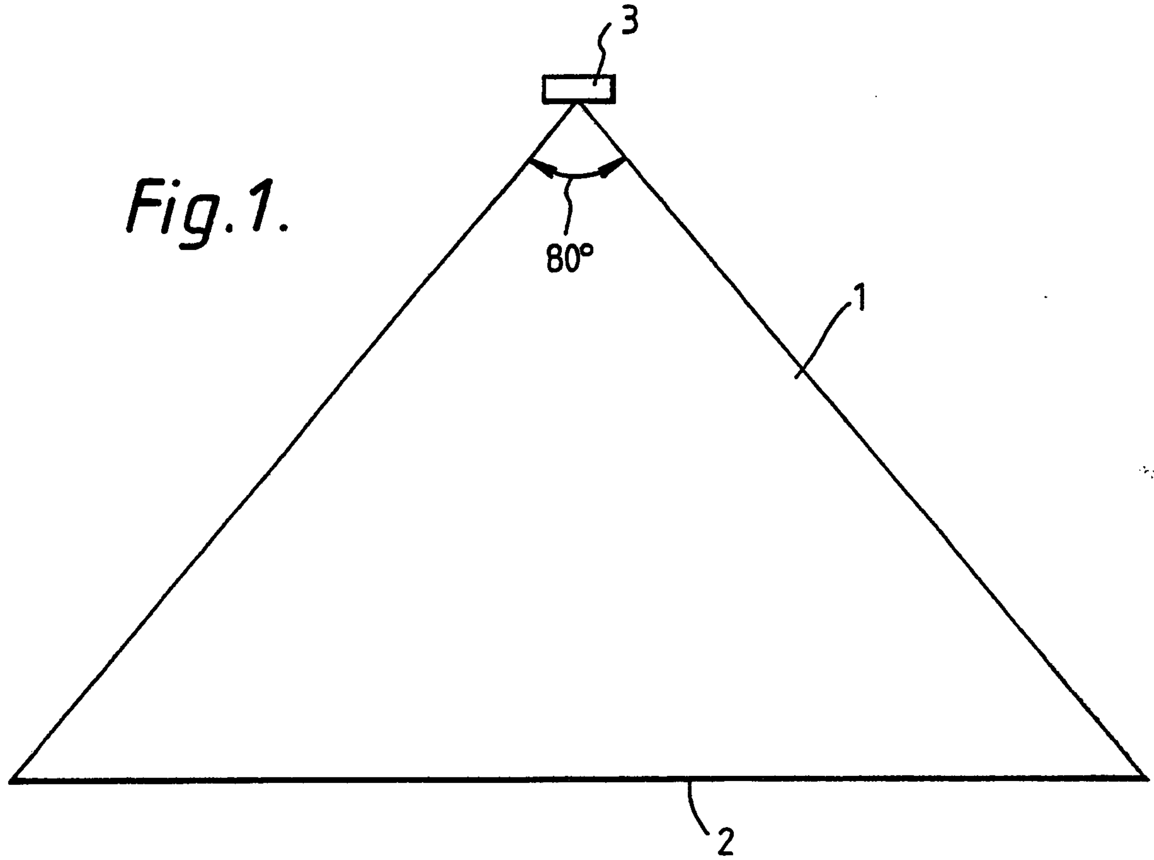


Fig.1.

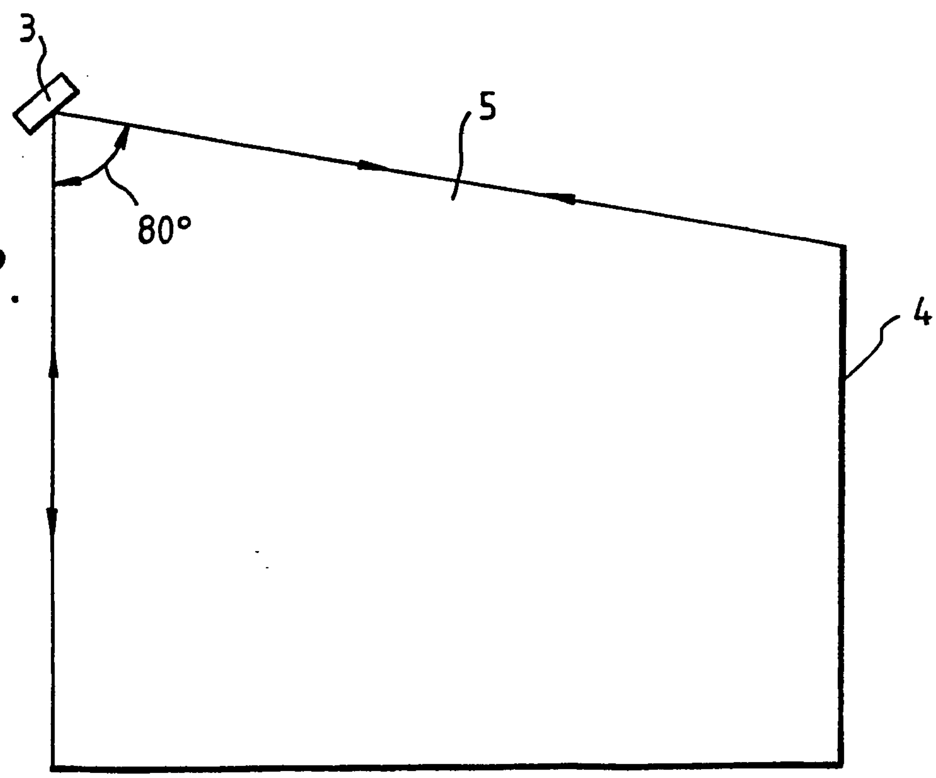


Fig.2.

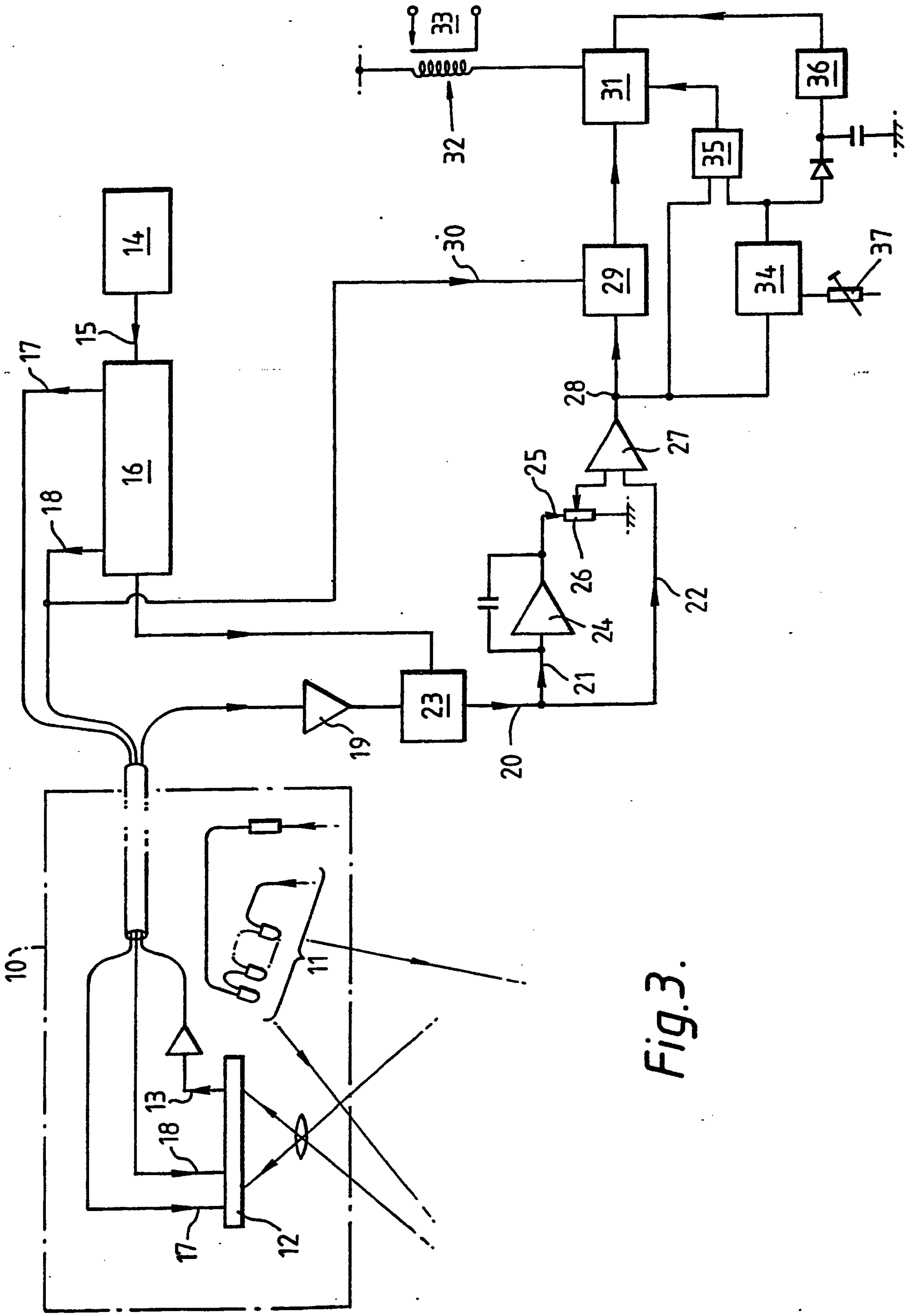
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Fig.3.

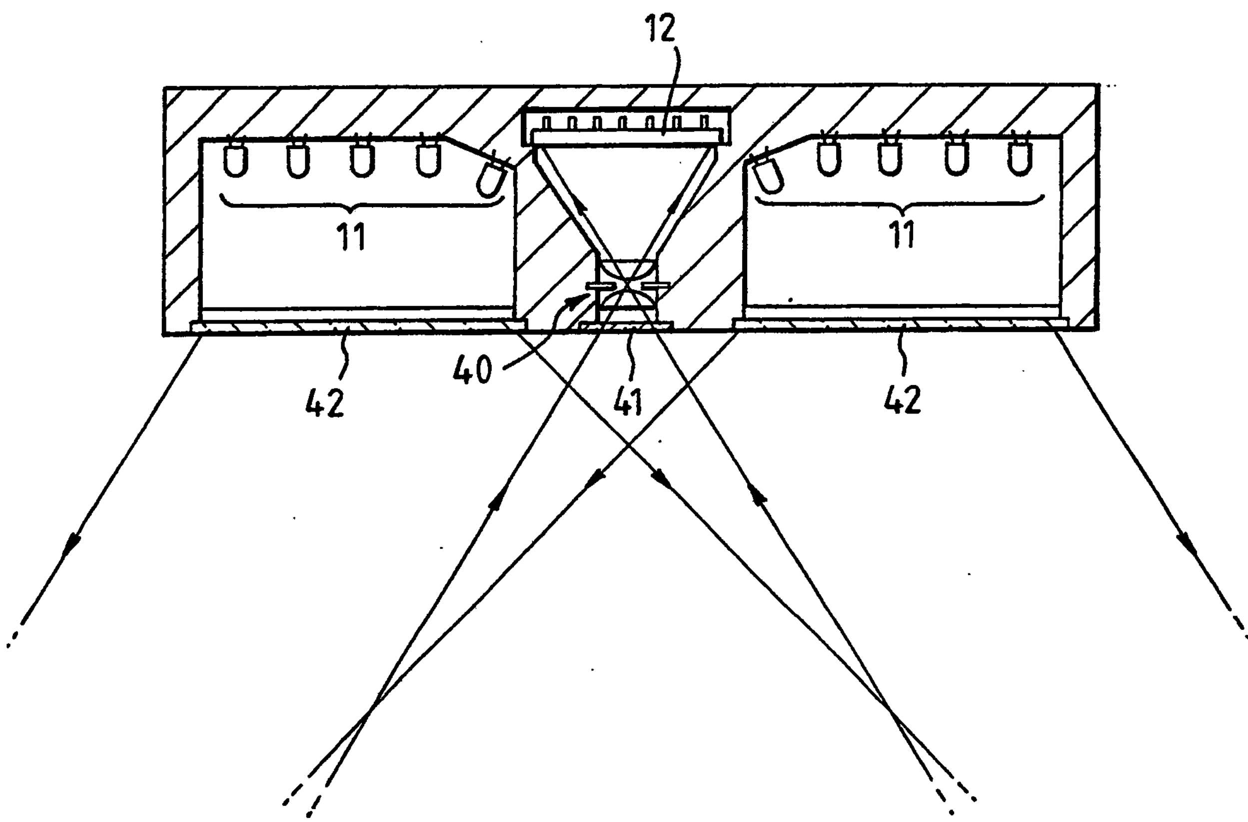


Fig.4.

# SAFETY SYSTEMS

This invention relates to safety systems and is more particularly, although not exclusively, concerned with safety zone protection systems.

One known form of a safety zone protection system is an obstruction detector, which operates to shut down machinery when an obstruction is detected in the vicinity of the machinery. Naturally, other applications of obstruction detectors are possible, for example, in lift doors where the detector operates to keep the doors open when an obstruction for the doors is present. However, obstruction detectors tend to suffer from the problem of not being able to give a precisely defined continuous "curtain" of sensitivity over a wide area. This may lead to there being unprotected regions within a defined protection area and also a restricted range of sensitivity of the detector.

According to the present invention, there is provided a safety system defining a surveillance zone in which the presence of an object is to be detected, the system comprising:

detector means for surveying the zone and for providing an output signal indicative of the surveillance zone;

reflector means positioned remote from the detector means and defining at least one boundary of the

surveillance zone;

illumination means for illuminating the reflector means with radiation to which the detector means is sensitive, the detector means receiving radiation reflected from the reflector means; and

processing means for receiving the output signal from the detector means and analysing the signal to provide an indication of the presence of any objects due to variations present in the surveillance zone.

Advantageously, the detector means is an infrared radiation sensitive camera, in which case the illumination means may comprise a plurality of infrared emitting photodiodes.

For a better understanding of the invention, reference will now be made, by way of example only, to the accompanying drawings in which:

Figure 1 is a schematic diagram of the geometry of a basic safety zone protection arrangement;

Figure 2 is a schematic diagram of the geometry of a further safety zone protection arrangement;

Figure 3 is a schematic circuit diagram corresponding to a complete zone protection system; and

Figure 4 is a simplified diagram of a camera assembly.

In Figure 1, a triangular sensitive area 1 is defined by the positions of a reflector strip 2 and a camera 3, the camera being positioned at an apex of the triangular area 1. The area 1 is isosceles in shape, and the camera 3 is spaced about 3m from the reflector strip 2 and has an angular field-of-view which is defined by its lens. A subtended angle of up to 80° is possible. The reflector strip 2 is mounted in the object plane of the camera 3, and its width is between 5mm and 25mm. Naturally, the wider the strip the greater the range of sensitivity. The strip 2 is chosen to be at least as long as the length of side of area 1 subtended by the angular field-of-view of

the camera lens. In the specific embodiment of Figure 1, with an angular field-of-view of 80°, and a spacing of 3m between the camera and the strip, the length of the reflector strip 2 is approximately 5m, and a "curtain" of sensitivity is defined by the triangular area 1.

However, depending on the quality of the lenses used in the optical system, this length may be reduced to around 4m.

In Figure 2, the triangular sensitive area of Figure 1 is extended by utilising an angled reflector strip 4. The camera 3 still subtends an angular field-of-view of 80° but the sensitive area 5 is approximately double that obtained in the Figure 1 arrangement.

In order to make the arrangements described in Figures 1 and 2 work, infrared light sources are fitted adjacent the camera (not shown) and these illuminate the reflector strip along its entire length so that the imaging array within the camera (see Figure 4) produces a large and even signal from the entire length of the strip when no obstructions are present. The infrared light sources may be infrared light emitting diodes.

When an obstruction appears in the sensitive area between the reflector strip 2 and the camera 3, a dark shadow is obtained on the imaging array within the camera. This is due to the difference in reflectivity between the reflector strip and the obstruction. The system to be described later may be adjusted to operate when a predetermined number of diodes or elements in the imaging array are obscured or blocked. This may obviate false activation of the system due to the presence of dirt or other small objects falling onto the strip and/or damage to the strip itself.

The operation of the system will now be described with reference to Figure 3. A camera assembly 10 (shown in more detail in Figure 4) includes a bank 11 of infrared diodes which illuminate the reflector strip (not shown),

and a linear photodiode array 12, which consists of an integrated circuit of the type used in bar code readers, and contains a linear array of 512 photodiodes, the array being approximately 12mm long. A system of shift registers (not shown) allows the electrical charges stored on the diodes to be read out in sequence as a video output signal 13. An oscillator 14 generates a "read" signal 15 which is passed to a divider unit 16. The unit 16 provides "start" and "clock" pulses, 17 and 18 respectively to the array 12 to drive the shift registers to provide the video output signal 13. Each full line scan is executed every 50ms, i.e. the video output from the array is obtained every 50ms this rate being dependent on the photosensitivity of the array and its response time to the presence of an obstruction. The video output 13 is passed to an amplifier 19 where an amplified signal 20 having a 1V peak-to-peak amplitude is generated. The amplified signal 20 is then split into two portions 21 and 22 after passing through a "black level" clamp 23. Portion 21 is integrated by an integrator unit 24 to form an integrated signal 25 having a time constant of approximately 1s. This signal 25 is used as a d.c. voltage signal having half the amplitude approximately of the original video signal 13 and is fed to a potentiometer 26 and in conjunction with a reference voltage allows a voltage value between the reference and the integrated voltage to be used to provide a trigger threshold voltage for a positive feedback comparator 27. The other portion 22 of the amplified signal 20 is applied to the input of the comparator 27. When no obstructions are present in the sensitive area, the comparator 27 switches "high" on receipt of the signal portion 22 corresponding to the reflector strip being scanned by the array 12 and then switches "low" when the scan is executed. This switched output 28 drives a clock input of a "count to two" counter circuit 29 and under normal conditions the circuit 29

simply cycles continually between '0' and '1' with a reset signal 30 for the counter circuit coming from the divider unit 16. The "black level" clamp 23 establishes a d.c. level corresponding to a "no signal" condition i.e. when the end of the scan occurs, an analogue gate (not shown) closes to link a signal input of the "count to two" circuit 29 to a reference voltage of about 1V. The gate opens when the new scan begins and therefore the amplified signal portions 21, 22 always start from this reference voltage and a "trigger level" can be defined with reference to this voltage i.e. the "no signal" state is clamped to this reference voltage. If however, one or more obstructions appear in the field-of-view of the camera, other switching edges will appear at the comparator output 28 due to one or more of the photodiodes in the array 12 being obscured. Under these conditions, the counter circuit 29 will reach '2' for some period during the scan. If this occurs, a trigger circuit/relay driver 31 is operated and a relay 32 is activated to operate a load 33 for example, machinery or lift doors etc. as long as the count '2' is received at the trigger circuit/relay driver 31.

However, the system described above may be defeated by obstructions which completely block a portion of the reflector during the scan or the entire reflector from view. The first of these obstructions, namely the blocked portion of the reflector, has the effect of shortening the length of the reflector strip and in which case no triggering will occur under these conditions. This problem is overcome by using a monostable device counter 34 to measure the pulse length being received by the camera i.e. signal 28 and to compare it with a set pulse width in pulse width comparator 35. Any significant reduction in pulse length will then trigger the circuit 31 as before.

entire reflector strip is blocked and the monostable 34 receives no trigger pulses. This is overcome by integrating the output from monostable device 34 and using the d.c. voltage derived to be applied to a pulse "present" detector 36 allowing it to rapidly decay as no pulses are received at monostable 34, the detector 36 including a trigger threshold (not shown). The monostable 34 is used to provide a preset time delay which is less than the pulse width of the video signal i.e. the signal corresponding to the length of the strip 2.

As shown the monostable is used in conjunction with a potentiometer 37, but a programmable counter is a more stable arrangement, the output state of the counter being changed after a preset number of clock pulses have occurred. This counter is reset by the "rising edge" of the video output and would count until the "falling edge" occurs, and if it does not reach its present value before the "falling edge" a trigger pulse is initiated.

The camera arrangement is shown in more detail in Figure 4. The arrangement comprises an imaging lens assembly 40 mounted behind an infrared filter 41 which focusses reflected light from the reflector strip onto a linear photodiode array 12 as described previously. Infrared diodes 11 (as described previously) are positioned on either side of the camera for projecting light onto the reflector strip via a pair of cylindrical lenses 42.

The overall size of the camera arrangement may be as little as 150mm in length and 50mm deep having a thickness of 12mm and can therefore be installed in a small space such as between a lift car and its landing doors.

If a larger coverage area is required, the infrared light source can be replaced by a diffused infrared light source, e.g. an illuminated polyethyl methacrylate strip about 12mm thick. Naturally the brightness at which the reflector strip is illuminated may be controlled by

varying the number of photodiodes used and/or the current passing through them as required.

If a different shaped sensitive area is required e.g. a rectangular area, two or more camera assemblies can be combined with their fields-of-view overlapping, or the reflector can be shaped to suit the geometry desired.

The system described above is insensitive to the nature of the object being detected e.g. colour, conductivity etc, and a reliable signal can be obtained on the presence of a small obstructing object within the sensitive area.

As the thickness of the sensitive area is accurately defined by the thickness of the reflector strip, the sensitive area can be fitted within a narrow gap between parts of machinery etc.

If the requirement allows, a linear diode array 12 may have 128 or 256 photodiodes.

Naturally, other infrared light sources may be used to illuminate the reflector strip 2, but these may be more expensive, e.g. a continuous wave (CW) semiconductor laser or less reliable e.g. incandescent lamps. However, the CW laser would provide an almost ideal light source which could be spread into a very narrow "fan" with almost its whole output concentrated on the strip 2. Advantageously, these lasers may be used in special, long range applications.

Other radiation sources may be used as illuminators, but may have disadvantages in particular applications. For example, visible light sources may be used but the camera may be saturated with ambient light causing confusion with the recognition processing. On the other hand visible radiation would render the "curtain" zone visible to persons passing through which may or may not be depending on the application to which the system is to be put.

Radio waves may be utilised in such a system, but the

detector would need to be a compatible device. However, these systems incorporating radio waves would be relatively insensitive to people as they are transparent at radio frequencies.

## CLAIMS

1. A safety system defining a surveillance zone in which the presence of an object is to be detected, the system comprising:

detector means for surveying the zone and for providing an output signal indicative of the surveillance zone;

reflector means positioned remote from the detector means and defining at least one boundary of the surveillance zone;

illumination means for illuminating the reflector means with radiation to which the detector means is sensitive, the detector means receiving radiation reflected from the reflector means; and

processing means for receiving the output signal from the detector means and analysing the signal to provide an indication of the presence of any objects due to variations present in the surveillance zone.

2. A safety system according to claim 1, wherein the detector means is an infrared radiation sensitive camera.

3. A safety system according to claim 2 wherein the illumination means comprises a plurality of infrared emitting photodiodes.

4. A safety system according to claim 2, wherein the illumination means is a continuous wave semicondctor laser.

5. A safety system according to claim 1, wherein the illumination means is a source of visible light and the detector means is a camera.

6. A safety system substantially as hereinbefore described with reference to the accompanying drawings.